AP® Physics 1: Algebra-Based Practice Exam

From the 2015 Administration

NOTE: This is a modified version of the 2015 AP Physics 1: Algebra-Based Exam.

Contents

Note: This publication shows the page numbers that appeared in the ***2014–15 AP Exam Instructions*** book and in the actual exam. This publication was not repaginated to begin with page 1.

Exam Instructions

The following contains instructions taken from the *2014–15 AP Exam Instructions* book.

AP® Physics 1: Algebra-Based Exam

Regularly Scheduled Exam Date: Wednesday afternoon, May 6, 2015

Late-Testing Exam Date: Thursday morning, May 21, 2015

Section I Total Time: 1 hr. 30 min.   Section II Total Time: 1 hr. 30 min.

AP® Physics 2: Algebra-Based Exam

Regularly Scheduled Exam Date: Thursday afternoon, May 7, 2015

Late-Testing Exam Date: Friday morning, May 22, 2015

Section I Total Time: 1 hr. 30 min.   Section II Total Time: 1 hr. 30 min.

Section I **Total Time:** 1 hour 30 minutes
Calculator allowed
Number of Questions: 50*
Percent of Total Score: 50%
Writing Instrument: Pencil required

**The number of questions may vary slightly depending on the form of the exam.*

Section II **Total Time:** 1 hour 30 minutes
Calculator allowed
Number of Questions Physics 1: 5
Number of Questions Physics 2: 4
Percent of Total Score: 50%
Writing Instrument: Pen with black or dark blue ink, or pencil

What Proctors Need to Bring to This Exam

- Exam packets
- Answer sheets
- AP Student Packs
- *2014-15 AP Coordinator's Manual*
- This book — *AP Exam Instructions*
- AP Exam Seating Chart template(s)
- School Code and Home-School/Self-Study Codes
- Extra calculators
- Extra rulers or straightedges
- Pencil sharpener
- Container for students' electronic devices (if needed)
- Extra No. 2 pencils with erasers
- Extra pens with black or dark blue ink
- Extra paper
- Stapler
- Watch
- Signs for the door to the testing room
  – "Exam in Progress"
  – "Cell phones are prohibited in the testing room"

Students are permitted to use rulers, straightedges, and four-function, scientific, or graphing calculators for these entire exams (Sections I and II). Before starting the exam administration, make sure each student has an appropriate calculator, and any student with a graphing calculator has a model from the approved list on page 46 of the *2014-15 AP Coordinator's Manual*. See pages 43–46 of the *2014-15 AP Coordinator's Manual* for more information. If a student does not have an appropriate calculator or has a graphing calculator not on the approved list, you may provide one from your supply. If the student does not want to use the calculator you provide or does not want to use a calculator at all, he or she must hand copy, date, and sign the release statement on page 44 of the *2014-15 AP Coordinator's Manual.*

Students may have no more than two calculators on their desks. Calculators may not be shared. Calculator memories do not need to be cleared before or after the exam. Students with Hewlett-Packard 48–50 Series and Casio FX-9860 graphing calculators may use cards designed for use with these calculators. Proctors should make sure infrared ports (Hewlett-Packard) are not facing each other. **Since graphing calculators can be used to store data, including text, proctors should monitor that students are using their calculators appropriately. Attempts by students to use the calculator to remove exam questions and/or answers from the room may result in the cancellation of AP Exam scores.**

Tables containing equations commonly used in physics are included in each AP exam booklet, for use during the entire exam. Students are NOT allowed to bring their own copies of the equation tables to the Exam room.

SECTION I: Multiple Choice

! Do not begin the exam instructions below until you have completed the appropriate General Instructions for your group.

Make sure you begin the exam at the designated time. Remember: You must complete a seating chart for this exam. See pages 279–280 for a seating chart template and instructions. See the *2014-15 AP Coordinator's Manual* for exam seating requirements (pages 48–50, 88).

Physics 1: Algebra-Based

If you are giving the regularly scheduled exam, say:

> **It is Wednesday afternoon, May 6, and you will be taking the AP Physics 1: Algebra-Based Exam.**

If you are giving the alternate exam for late testing, say:

> **It is Thursday morning, May 21, and you will be taking the AP Physics 1: Algebra-Based Exam.**

Physics 2: Algebra-Based

If you are giving the regularly scheduled exam, say:

> **It is Thursday afternoon, May 7, and you will be taking the AP Physics 2: Algebra-Based Exam.**

If you are giving the alternate exam for late testing, say:

> **It is Friday morning, May 22, and you will be taking the AP Physics 2: Algebra-Based Exam.**

> **In a moment, you will open the packet that contains your exam materials. By opening this packet, you agree to all of the AP Program's policies and procedures outlined in the *2014-15 Bulletin for AP Students and Parents*. You may now remove the shrinkwrap from your exam packet and take out the Section I booklet, but do not open the booklet or the shrinkwrapped Section II materials. Put the white seals aside. . . .**

> **Carefully remove the AP Exam label found near the top left of your exam booklet cover. Now place it on page 1 of your answer sheet on the light blue box near the top right-hand corner that reads "AP Exam Label."**

If students accidentally place the exam label in the space for the number label or vice versa, advise them to leave the labels in place. They should not try to remove the label; their exam will be processed correctly.

> **Read the statements on the front cover of Section I and look up when you have finished. . . .**
>
> **Sign your name and write today's date. Look up when you have finished. . . .**
>
> **Now print your full legal name where indicated. Are there any questions? . . .**
>
> **Turn to the back cover and read it completely. Look up when you have finished. . . .**
>
> **Are there any questions? . . .**
>
> **You will now take the multiple-choice portion of the exam. You should have in front of you the multiple-choice booklet and your answer sheet. You may never discuss these specific multiple-choice questions at any time in any form with anyone, including your teacher and other students. If you disclose these questions through any means, your AP Exam score will be canceled. . . .**
>
> **You must complete the answer sheet using a No. 2 pencil only. Mark all of your responses on pages 2 and 3 of your answer sheet. Remember, for numbers 1 through 45 on answer sheet page 2, mark only the single best answer to each question. For numbers 131 through 135 at the bottom of answer sheet page 3, mark the <u>two</u> best answer choices for each question. Completely fill in the circles. If you need to erase, do so carefully and completely. No credit will be given for anything written in the exam booklet. Scratch paper is not allowed, but you may use the margins or any blank space in the exam booklet for scratch work. Rulers, straightedges, and calculators may be used for the entire exam. You may place these items on your desk. Are there any questions? . . .**
>
> **You have 1 hour and 30 minutes for this section. Open your Section I booklet and begin.**

Note Start Time here __________. Note Stop Time here __________. Check that students are marking their answers in pencil on their answer sheets, and that they are not looking at their shrinkwrapped Section II booklets. After 1 hour and 20 minutes, say:

> **There are 10 minutes remaining.**

After 10 minutes, say:

> **Stop working. Close your booklet and put your answer sheet on your desk, face up. Make sure you have your AP number label and an AP Exam label on page 1 of your answer sheet. Sit quietly while I collect your answer sheets.**

Collect an answer sheet from each student. Check that each answer sheet has an AP number label and an AP Exam label. After all answer sheets have been collected, say:

> **Now you must seal your exam booklet using the white seals you set aside earlier. Remove the white seals from the backing and press one on each area of your exam booklet cover marked "PLACE SEAL HERE." Fold each seal over**

the back cover. When you have finished, place the booklet on your desk, face up. I will now collect your Section I booklet. . . .

Collect a Section I booklet from each student. Check that each student has signed the front cover of the sealed Section I booklet.

There is a 10-minute break between Sections I and II. When all Section I materials have been collected and accounted for and you are ready for the break, say:

Please listen carefully to these instructions before we take a 10-minute break. Please put all of your calculators under your chair. Your calculators and all items you placed under your chair at the beginning of this exam must stay there, and you are not permitted to open or access them in any way. Leave your shrinkwrapped Section II packet on your desk during the break. You are not allowed to consult teachers, other students, or textbooks during the break. You may not make phone calls, send text messages, check email, use a social networking site, or access any electronic or communication device. Remember, you may never discuss the multiple-choice questions at any time in any form with anyone, including your teacher and other students. If you disclose these questions through any means, your AP Exam score will be canceled. Are there any questions? . . .

You may begin your break. Testing will resume at __________.

SECTION II: Free Response

After the break, say:

May I have everyone's attention? Place your Student Pack on your desk. . . .

You may now remove the shrinkwrap from the Section II packet, but do not open the exam booklet until you are told to do so. . . .

Read the bulleted statements on the front cover of the exam booklet. Look up when you have finished. . . .

Now place an AP number label on the shaded box. If you don't have any AP number labels, write your AP number in the box. Look up when you have finished. . . .

Read the last statement. . . .

Using your pen, print the first, middle and last initials of your legal name in the boxes and print today's date where indicated. This constitutes your signature and your agreement to the statements on the front cover. . . .

Turn to the back cover and complete Item 1 under "Important Identification Information." Print the first two letters of your <u>last</u> name and the first letter of your <u>first</u> name in the boxes. Look up when you have finished. . . .

In Item 2, print your date of birth in the boxes. . . .

In Item 3, write the school code you printed on the front of your Student Pack in the boxes. . . .

Read Item 4. . . .

I need to collect the Student Pack from anyone who will be taking another AP Exam. You may keep it only if you are not taking any other AP Exams this year. If you have no other AP Exams to take, place your Student Pack under your chair now. . . .

While Student Packs are being collected, read the information on the back cover of the exam booklet. Do not open the booklet until you are told to do so. Look up when you have finished. . . .

Collect the Student Packs. Then say:

Are there any questions? . . .

Rulers, straightedges, and calculators may be used for Section II. Be sure these items are on your desk. . . .

You have 1 hour and 30 minutes to complete Section II. You are responsible for pacing yourself, and you may proceed freely from one question to the next.

If you are giving the AP Physics 1: Algebra-Based Exam, say:

Section II has 5 questions. It is suggested that you spend approximately 25 minutes each for questions 2 and 3, and 13 minutes each for questions 1, 4, and 5.

If you are giving the AP Physics 2: Algebra-Based Exam, say:

Section II has 4 questions. It is suggested that you spend approximately 25 minutes each for questions 2 and 3, and 20 minutes each for questions 1 and 4.

You must write your answers in the exam booklet using a pen with black or dark blue ink or a No. 2 pencil. If you use a pencil, be sure that your writing is dark enough to be easily read. If you need more paper during the exam, raise your hand. At the top of each extra sheet of paper you use, be sure to write only your AP number and the number of the question you are working on. Do not write your name. Are there any questions? . . .

You may begin.

Note Start Time here ___________. Note Stop Time here ___________. You should also make sure that Hewlett-Packard calculators' infrared ports are not facing each other and that students are not sharing calculators. After 1 hour and 20 minutes, say:

There are 10 minutes remaining.

After 10 minutes, say:

Stop working and close your exam booklet. Place it on your desk, face up. . . .

If any students used extra paper for the free-response section, have those students staple the extra sheet(s) to the first page corresponding to that question in their exam booklets. Complete an

Incident Report and include any exam booklets with extra sheets of paper in an Incident Report return envelope (see page 57 of the *AP Coordinator's Manual* for details). Then say:

> **Remain in your seat, without talking, while the exam materials are collected. . . .**

Collect a Section II booklet from each student. Check for the following:

- Exam booklet front cover: The student placed an AP number label on the shaded box, and printed his or her initials and today's date.
- Exam booklet back cover: The student completed the "Important Identification Information" area.

When all exam materials have been collected and accounted for, return to students any electronic devices you may have collected before the start of the exam.

If you are giving the regularly scheduled exam, say:

> **You may not discuss or share these specific free-response questions with anyone unless they are released on the College Board website in about two days. Your AP Exam score results will be available online in July.**

If you are giving the alternate exam for late testing, say:

> **None of the questions in this exam may ever be discussed or shared in any way at any time. Your AP Exam score results will be available online in July.**

If any students completed the AP number card at the beginning of this exam, say:

> **Please remember to take your AP number card with you. You will need the information on this card to view your scores and order AP score reporting services online.**

Then say:

> **You are now dismissed.**

All exam materials must be placed in secure storage until they are returned to the AP Program after your school's last administration. Before storing materials, check the "School Use Only" section on page 1 of the answer sheet and:

- Fill in the appropriate section number circle in order to access a separate AP Instructional Planning Report (for regularly scheduled exams only) or subject score roster at the class section or teacher level. See "Post-Exam Activities" in the *2014-15 AP Coordinator's Manual*.
- Check your list of students who are eligible for fee reductions and fill in the appropriate circle on their registration answer sheets.

Be sure to give the completed seating chart to the AP Coordinator. Schools must retain seating charts for at least six months (unless the state or district requires that they be retained for a longer period of time). Schools should not return any seating charts in their exam shipments unless they are required as part of an Incident Report.

Student Answer Sheet for the Multiple-Choice Section

Use this section to capture student responses. (Note that the following answer sheet is a sample, and may differ from one used in an actual exam.)

AP Answer Sheet 2015

AP Number Label
(from Student Pack)

B123456789T

AP Exam Label
(from Section I Booklet)

CollegeBoard

COMPLETE THIS AREA AT EVERY EXAM. USE NO. 2 PENCIL ONLY

To maintain the security of the exam and the validity of my AP score, I will allow no one else to see the multiple-choice questions. I will seal the multiple-choice booklet when asked to do so, and I will not discuss these questions with anyone at any time after completing the section. I am aware of and agree to the AP Program's policies and procedures as outlined in the *2014-15 Bulletin for AP Students and Parents*, including using testing accommodations (e.g., extended time, computer, etc.) only if I have been preapproved by College Board Services for Students with Disabilities.

A. SIGNATURE — Sign your legal name as it will appear on your college applications. — Date

B. LEGAL NAME — Omit apostrophes, Jr., II.

Legal Last Name — First 15 Letters | Legal First Name — First 12 Letters | MI

C. YOUR AP NUMBER

D. EXAM DATE — Month | Day

E. EXAM START TIME — AM | PM

F. MULTIPLE-CHOICE BOOKLET SERIAL NUMBER — S

G. ONLINE PROVIDER CODE

H. AP EXAM I AM TAKING USING THIS ANSWER SHEET — Exam Name: | Form: | Form Code:

779934

SCHOOL USE ONLY

Section Number: 1 2 3 4 5 6 7 8 9

Fee Reduction Granted: 1 Option 1 — 2 Option 2

COMPLETE THIS AREA ONLY ONCE.

I. AREA CODE AND PHONE NUMBER

INTERNATIONAL PHONE

J. SCHOOL YOU ATTEND

SCHOOL CODE — School Name — City — State — Country

K. DATE OF BIRTH — Month | Day | Year

Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec

L. SOCIAL SECURITY NUMBER (Optional)

M. COLLEGE TO RECEIVE YOUR AP SCORE REPORT

COLLEGE CODE — Using the college code listed in the AP Student Pack, indicate the **ONE** college that you want to receive your AP score report.

College Name — City — State — Country

N. CURRENT GRADE LEVEL

- Not yet in 9th grade
- 9th
- 10th
- 11th
- 12th
- No longer in high school

COMPLETE THIS AREA AT EACH EXAM (IF APPLICABLE).

O. SURVEY QUESTIONS — Answer the survey questions in the AP Student Pack. Do not put responses to exam questions in this section.

1	A B C D E F G H I	4	A B C D E F G H I	7	A B C D E F G H I
2	A B C D E F G H I	5	A B C D E F G H I	8	A B C D E F G H I
3	A B C D E F G H I	6	A B C D E F G H I	9	A B C D E F G H I

P. LANGUAGE — Do not complete this section unless instructed to do so.

If this answer sheet is for the French Language and Culture, German Language and Culture, Italian Language and Culture, Spanish Language and Culture, or Spanish Literature and Culture Exam, please answer the following questions. Your responses will not affect your score.

1. Have you lived or studied for one month or more in a country where the language of the exam you are now taking is spoken?

   Yes No

2. Do you regularly speak or hear the language at home?

   Yes No

QUESTIONS 1–75

Indicate your answers to the exam questions in this section (pages 2 and 3). Mark only one response per question for Questions 1 through 120. If a question has only four answer options, do not mark option E. Answers written in the multiple-choice booklet will not be scored.

COMPLETE MARK ● EXAMPLES OF INCOMPLETE MARKS

You must use a No. 2 pencil and marks must be complete. Do not use a mechanical pencil. It is very important that you fill in the entire circle darkly and completely. If you change your response, erase as completely as possible. Incomplete marks or erasures may affect your score.

1	A B C D E	26	A B C D E	51	A B C D E
2	A B C D E	27	A B C D E	52	A B C D E
3	A B C D E	28	A B C D E	53	A B C D E
4	A B C D E	29	A B C D E	54	A B C D E
5	A B C D E	30	A B C D E	55	A B C D E
6	A B C D E	31	A B C D E	56	A B C D E
7	A B C D E	32	A B C D E	57	A B C D E
8	A B C D E	33	A B C D E	58	A B C D E
9	A B C D E	34	A B C D E	59	A B C D E
10	A B C D E	35	A B C D E	60	A B C D E
11	A B C D E	36	A B C D E	61	A B C D E
12	A B C D E	37	A B C D E	62	A B C D E
13	A B C D E	38	A B C D E	63	A B C D E
14	A B C D E	39	A B C D E	64	A B C D E
15	A B C D E	40	A B C D E	65	A B C D E
16	A B C D E	41	A B C D E	66	A B C D E
17	A B C D E	42	A B C D E	67	A B C D E
18	A B C D E	43	A B C D E	68	A B C D E
19	A B C D E	44	A B C D E	69	A B C D E
20	A B C D E	45	A B C D E	70	A B C D E
21	A B C D E	46	A B C D E	71	A B C D E
22	A B C D E	47	A B C D E	72	A B C D E
23	A B C D E	48	A B C D E	73	A B C D E
24	A B C D E	49	A B C D E	74	A B C D E
25	A B C D E	50	A B C D E	75	A B C D E

ETS USE ONLY

Exam		0 1 2 3 4 5 6 7 8 9
		0 1 2 3 4 5 6 7 8 9
Exam		0 1 2 3 4 5 6 7 8 9
		0 1 2 3 4 5 6 7 8 9

SELECTED MEDIA EXAMS	R	W	O	OTHER EXAMS	R	W	O
PT02				TOTAL			
PT03				Subscore (if applicable)			
PT04				Subscore (if applicable)			

DO NOT WRITE IN THIS AREA

QUESTIONS 76–120

Be sure each mark is dark and completely fills the circle. If a question has only four answer options, do not mark option E.

76 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	91 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	106 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
77 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	92 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	107 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
78 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	93 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	108 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
79 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	94 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	109 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
80 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	95 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	110 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
81 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	96 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	111 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
82 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	97 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	112 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
83 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	98 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	113 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
84 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	99 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	114 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
85 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	100 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	115 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
86 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	101 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	116 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
87 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	102 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	117 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
88 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	103 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	118 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
89 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	104 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	119 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
90 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	105 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	120 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ

QUESTIONS 121–126

For Students Taking AP Biology

Write your answer in the boxes at the top of the griddable area and fill in the corresponding circles. Mark only one circle in any column. You will receive credit only if the circles are filled in correctly.

Each of questions 121, 122, 123, 124, 125 and 126 has a grid of six answer boxes with these circles:

		/	/	/	
–	.	.	.	.	.
		0	0	0	0
	1	1	1	1	1
	2	2	2	2	2
	3	3	3	3	3
	4	4	4	4	4
	5	5	5	5	5
	6	6	6	6	6
	7	7	7	7	7
	8	8	8	8	8
	9	9	9	9	9

QUESTIONS 131–142

For Students Taking AP Physics 1 or AP Physics 2

Mark two responses per question. You will receive credit only if both correct responses are selected.

131 Ⓐ Ⓑ Ⓒ Ⓓ	135 Ⓐ Ⓑ Ⓒ Ⓓ	139 Ⓐ Ⓑ Ⓒ Ⓓ
132 Ⓐ Ⓑ Ⓒ Ⓓ	136 Ⓐ Ⓑ Ⓒ Ⓓ	140 Ⓐ Ⓑ Ⓒ Ⓓ
133 Ⓐ Ⓑ Ⓒ Ⓓ	137 Ⓐ Ⓑ Ⓒ Ⓓ	141 Ⓐ Ⓑ Ⓒ Ⓓ
134 Ⓐ Ⓑ Ⓒ Ⓓ	138 Ⓐ Ⓑ Ⓒ Ⓓ	142 Ⓐ Ⓑ Ⓒ Ⓓ

DO NOT WRITE IN THIS AREA

COMPLETE THIS AREA ONLY ONCE.

Q. YOUR MAILING ADDRESS

Use the address abbreviations from your AP Student Pack. Fill in only one circle per column. Indicate a space in your address by leaving a blank box; do not grid that column.

STREET ADDRESS (include street number, street name, apartment number, etc.)

CITY

STATE

AK, AL, AR, AZ, CA, CO, CT, DC, DE, FL, GA, HI, IA, ID, IL, IN, KS, KY, LA, MA, MD, ME, MI, MN, MO, MS, MT, NC, ND, NE, NH, NJ, NM, NV, NY, OH, OK, OR, PA, RI, SC, SD, TN, TX, UT, VA, VT, WA, WI, WV, WY, Puerto Rico, AA, AE, AP, Other

ZIP OR POSTAL CODE

COUNTRY CODE

U. STUDENT SEARCH SERVICE®

Colleges and scholarship programs may request your information to inform you of educational opportunities and financial aid.

Would you like us to supply your information?

- Yes
- No

If you don't answer and previously chose to participate in this service, we will continue providing your information.

V. SEX

- Female
- Male

W. WHICH LANGUAGE DO YOU KNOW BEST?

- English
- English and another language about the same
- Another language

X. ETHNICITY/RACE

- American Indian or Alaska Native
- Asian, Asian American or Pacific Islander
- Black or African American
- Mexican or Mexican American
- Puerto Rican
- Other Hispanic, Latino or Latin American
- White
- Other

Y. PARENTAL EDUCATION LEVEL

In the first column, indicate the highest level of education of your parent/guardian. If you have two parents/guardians, indicate the level of education for your other parent/guardian in the second column. In the appropriate column for each parent/guardian, indicate whether this is your mother or female guardian or your father or male guardian.

- Grade school
- Some high school
- High school diploma or equivalent
- Vocational or trade school
- Some college
- Associate or two-year degree
- Bachelor's or four-year degree
- Some graduate or professional school
- Graduate or professional degree

- Mother or female guardian
- Father or male guardian

R. FOR STUDENTS OUTSIDE THE UNITED STATES ONLY

If your address does not fit in the spaces provided in Item Q, fill in as many circles as you can, then fill in the circle in Item R and print the remainder of your address in the spaces provided.

Address	City	State or Province	Country	ZIP or Postal Code

S. STUDENT IDENTIFIER (Student ID Number)

T. EMAIL ADDRESS

By providing your email address, you are granting the College Board permission to use your email in accordance with the policies in the *2014-15 Bulletin for AP Students and Parents.*

Section I: Multiple-Choice Questions

This is the multiple-choice section of the 2015 AP exam. It includes cover material and other administrative instructions to help familiarize students with the mechanics of the exam. (Note that future exams may differ in look from the following content.)

For purposes of test security and/or statistical analysis, some questions have been removed from the version of the exam that was administered in 2015. Therefore, the timing indicated here may not be appropriate for a practice exam.

PLACE SEAL HERE

AP® Physics 1: Algebra-Based Exam

SECTION I: Multiple Choice

2015

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

At a Glance

Total Time
1 hour, 30 minutes
Number of Questions
40
Percent of Total Score
50%
Writing Instrument
Pencil required
Electronic Device
Calculator allowed

Instructions

Section I of this exam contains 40 multiple-choice questions. Pages containing equations and other information are also printed in this booklet. Calculators, rulers, and straightedges may be used in this section.

Indicate all of your answers to the multiple-choice questions on the answer sheet. No credit will be given for anything written in this exam booklet, but you may use the booklet for notes or scratch work.

Because this section offers only four answer options for each question, do not mark the (E) answer circle for any question. If you change an answer, be sure that the previous mark is erased completely.

For questions 1 through 36, select the single best answer choice for each question. After you have decided which of the choices is best, completely fill in the corresponding circle on the answer sheet. Here is a sample question and answer.

Sample Question	Sample Answer
Chicago is a (A) state (B) city (C) country (D) continent	Ⓐ ● Ⓒ Ⓓ Ⓔ

For questions 131 through 134, select the two best answer choices for each question. After you have decided which two choices are best, completely fill in the two corresponding circles on the answer sheet. Here is a sample question and answer.

Sample Question	Sample Answer
New York is a (A) state (B) city (C) country (D) continent	● ● Ⓒ Ⓓ

Use your time effectively, working as quickly as you can without losing accuracy. Do not spend too much time on any one question. Go on to other questions and come back to the ones you have not answered if you have time. It is not expected that everyone will know the answers to all of the multiple-choice questions.

Your total score on Section I is based only on the number of questions answered correctly. Points are not deducted for incorrect answers or unanswered questions.

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Form I
Form Code 4LBP4-S

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DO NOT seal answer sheet inside

AP® PHYSICS 1 TABLE OF INFORMATION

CONSTANTS AND CONVERSION FACTORS			
Proton mass,	$m_p = 1.67 \times 10^{-27}$ kg	Electron charge magnitude,	$e = 1.60 \times 10^{-19}$ C
Neutron mass,	$m_n = 1.67 \times 10^{-27}$ kg	Coulomb's law constant,	$k = 1/4\pi\varepsilon_0 = 9.0 \times 10^9\ \mathrm{N{\cdot}m^2/C^2}$
Electron mass,	$m_e = 9.11 \times 10^{-31}$ kg	Universal gravitational constant,	$G = 6.67 \times 10^{-11}\ \mathrm{m^3/kg{\cdot}s^2}$
Speed of light,	$c = 3.00 \times 10^8$ m/s	Acceleration due to gravity at Earth's surface,	$g = 9.8\ \mathrm{m/s^2}$

UNIT SYMBOLS								
	meter,	m	kelvin,	K	watt,	W	degree Celsius,	°C
	kilogram,	kg	hertz,	Hz	coulomb,	C		
	second,	s	newton,	N	volt,	V		
	ampere,	A	joule,	J	ohm,	Ω		

PREFIXES		
Factor	Prefix	Symbol
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p

VALUES OF TRIGONOMETRIC FUNCTIONS FOR COMMON ANGLES

θ	0°	30°	37°	45°	53°	60°	90°
$\sin\theta$	0	$1/2$	$3/5$	$\sqrt{2}/2$	$4/5$	$\sqrt{3}/2$	1
$\cos\theta$	1	$\sqrt{3}/2$	$4/5$	$\sqrt{2}/2$	$3/5$	$1/2$	0
$\tan\theta$	0	$\sqrt{3}/3$	$3/4$	1	$4/3$	$\sqrt{3}$	∞

The following conventions are used in this exam.

I. The frame of reference of any problem is assumed to be inertial unless otherwise stated.
II. Assume air resistance is negligible unless otherwise stated.
III. In all situations, positive work is defined as work done on a system.
IV. The direction of current is conventional current: the direction in which positive charge would drift.
V. Assume all batteries and meters are ideal unless otherwise stated.

AP® PHYSICS 1 EQUATIONS

MECHANICS

$v_x = v_{x0} + a_x t$

$x = x_0 + v_{x0} t + \frac{1}{2} a_x t^2$

$v_x^2 = v_{x0}^2 + 2a_x (x - x_0)$

$\vec{a} = \frac{\sum \vec{F}}{m} = \frac{\vec{F}_{net}}{m}$

$\left|\vec{F}_f\right| \leq \mu \left|\vec{F}_n\right|$

$a_c = \frac{v^2}{r}$

$\vec{p} = m\vec{v}$

$\Delta \vec{p} = \vec{F}\,\Delta t$

$K = \frac{1}{2} m v^2$

$\Delta E = W = F_{\|} d = F d \cos\theta$

$P = \frac{\Delta E}{\Delta t}$

$\theta = \theta_0 + \omega_0 t + \frac{1}{2} \alpha t^2$

$\omega = \omega_0 + \alpha t$

$x = A\cos(2\pi f t)$

$\vec{\alpha} = \frac{\sum \vec{\tau}}{I} = \frac{\vec{\tau}_{net}}{I}$

$\tau = r_{\perp} F = r F \sin\theta$

$L = I\omega$

$\Delta L = \tau\,\Delta t$

$K = \frac{1}{2} I \omega^2$

$\left|\vec{F}_s\right| = k\left|\vec{x}\right|$

$U_s = \frac{1}{2} k x^2$

$\rho = \frac{m}{V}$

a = acceleration
A = amplitude
d = distance
E = energy
f = frequency
F = force
I = rotational inertia
K = kinetic energy
k = spring constant
L = angular momentum
ℓ = length
m = mass
P = power
p = momentum
r = radius or separation
T = period
t = time
U = potential energy
V = volume
v = speed
W = work done on a system
x = position
y = height
α = angular acceleration
μ = coefficient of friction
θ = angle
ρ = density
τ = torque
ω = angular speed

$\Delta U_g = m g \Delta y$

$T = \frac{2\pi}{\omega} = \frac{1}{f}$

$T_s = 2\pi\sqrt{\frac{m}{k}}$

$T_p = 2\pi\sqrt{\frac{\ell}{g}}$

$\left|\vec{F}_g\right| = G\frac{m_1 m_2}{r^2}$

$\vec{g} = \frac{\vec{F}_g}{m}$

$U_G = -\frac{G m_1 m_2}{r}$

ELECTRICITY

$\left|\vec{F}_E\right| = k\left|\frac{q_1 q_2}{r^2}\right|$

$I = \frac{\Delta q}{\Delta t}$

$R = \frac{\rho \ell}{A}$

$I = \frac{\Delta V}{R}$

$P = I\,\Delta V$

$R_s = \sum_i R_i$

$\frac{1}{R_p} = \sum_i \frac{1}{R_i}$

A = area
F = force
I = current
ℓ = length
P = power
q = charge
R = resistance
r = separation
t = time
V = electric potential
ρ = resistivity

WAVES

$\lambda = \frac{v}{f}$

f = frequency
v = speed
λ = wavelength

GEOMETRY AND TRIGONOMETRY

Rectangle
$A = bh$

Triangle
$A = \frac{1}{2} bh$

Circle
$A = \pi r^2$
$C = 2\pi r$

Rectangular solid
$V = \ell w h$

Cylinder
$V = \pi r^2 \ell$
$S = 2\pi r \ell + 2\pi r^2$

Sphere
$V = \frac{4}{3}\pi r^3$
$S = 4\pi r^2$

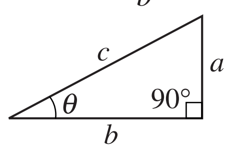
A = area
C = circumference
V = volume
S = surface area
b = base
h = height
ℓ = length
w = width
r = radius

Right triangle
$c^2 = a^2 + b^2$

$\sin\theta = \frac{a}{c}$

$\cos\theta = \frac{b}{c}$

$\tan\theta = \frac{a}{b}$



PHYSICS 1

Section I

40 Questions

Time—90 minutes

Note: To simplify calculations, you may use $g = 10 \text{ m/s}^2$ in all problems.

Directions: Each of the questions or incomplete statements below is followed by four suggested answers or completions. Select the one that is best in each case and then fill in the corresponding circle on the answer sheet.

1. In which of the following situations is the kinetic energy of the object decreasing?

   (A) A sphere is dropped from a building.
   (B) A satellite is moving in a circular orbit around Earth.
   (C) A baseball is heading upward after being thrown at an angle.
   (D) An elevator is moving upward at a constant velocity.

2. Two protons are held a distance *d* apart. The electrostatic force and the gravitational force that one proton exerts on the other are F_e and F_g, respectively. Which of the following correctly compares the magnitude and direction of these forces?

	Magnitude	Direction
(A)	$F_e > F_g$	Opposite
(B)	$F_e > F_g$	Same
(C)	$F_e < F_g$	Opposite
(D)	$F_e < F_g$	Same

3. A 2 kg object traveling at 5 m/s on a frictionless horizontal surface collides head-on with and sticks to a 3 kg object initially at rest. Which of the following correctly identifies the change in total kinetic energy and the resulting speed of the objects after the collision?

	Kinetic Energy	Speed
(A)	Increases	2 m/s
(B)	Increases	3.2 m/s
(C)	Decreases	2 m/s
(D)	Decreases	3.2 m/s

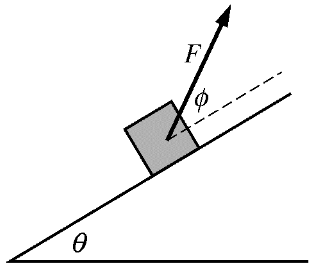
4. A stone of mass m is thrown upward at a $30°$ angle to the horizontal. At the instant the stone reaches its highest point, why is the stone neither gaining nor losing speed?

   (A) Because the acceleration of the stone at that instant is zero
   (B) Because the net force acting upon the stone at that instant has magnitude $m\vec{g}$
   (C) Because the angle between the stone's velocity and the net force exerted upon the stone is $90°$
   (D) Because the stone follows a parabolic trajectory and the peak of the trajectory is where the parabola has zero slope

5. A small cart is rolling freely on an inclined ramp with a constant acceleration of 0.50 m/s^2 in the $-x$-direction. At time $t = 0$, the cart has a velocity of 2.0 m/s in the $+x$-direction. If the cart never leaves the ramp, which of the following statements correctly describes the motion of the cart at a time $t > 5 \text{ s}$?

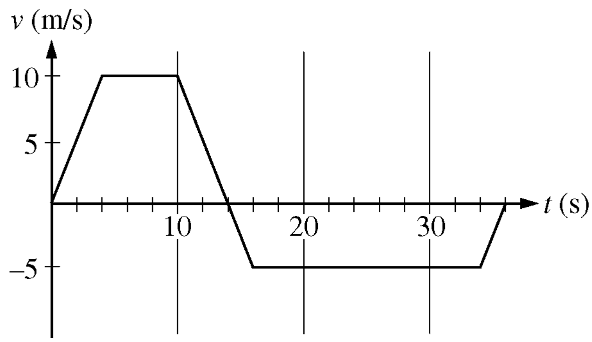
(A) The cart is traveling in the $+x$-direction and is slowing down.
(B) The cart is traveling in the $+x$-direction and is speeding up.
(C) The cart is traveling in the $-x$-direction and is slowing down.
(D) The cart is traveling in the $-x$-direction and is speeding up.

Item 6 was not scored.



7. A box of mass m is on a rough inclined plane that is at an angle θ with the horizontal. A force of magnitude F at an angle ϕ with the plane is exerted on the block, as shown above. As the block moves up the plane, there is a frictional force between the box and the plane of magnitude f. What is the magnitude of the net force acting on the box?

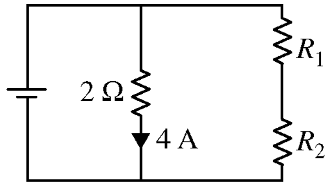
(A) $F\sin\phi - mg\cos\theta - f$
(B) $F\cos(\phi + \theta) + mg\sin\theta - f$
(C) $F\cos\phi - mg\sin\theta - f$
(D) $F\cos(\phi + \theta) - mg\sin\theta - f$



8. An object's velocity v as a function of time t is given in the graph above. Which of the following statements is true about the motion of the object?

(A) The object is not moving from $t = 4 \text{ s}$ to $t = 10 \text{ s}$.
(B) The object's initial and final positions are the same.
(C) The object is slowing down from $t = 14 \text{ s}$ to $t = 16 \text{ s}$.
(D) The average acceleration of the object from $t = 0 \text{ s}$ to $t = 4 \text{ s}$ is different from the acceleration from $t = 34 \text{ s}$ to $t = 36 \text{ s}$.

Questions 9-10 refer to the following material.



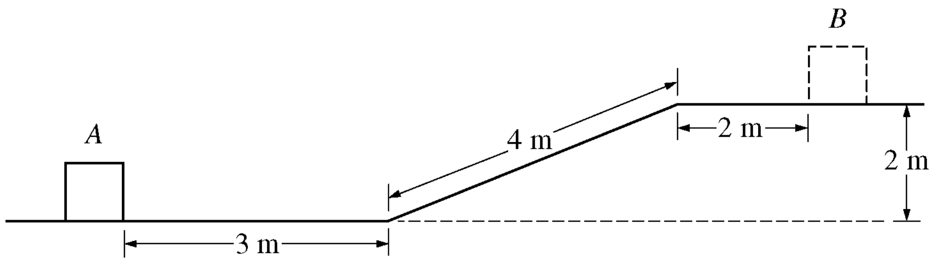
In the circuit shown above, the sum of the resistances of resistors R_1 and R_2 is $8\ \Omega$.

9. What is the current through the battery?

(A) 4 A
(B) 5 A
(C) 8 A
(D) 20 A

10. Resistor R_1 and the $2\ \Omega$ resistor are now swapped. How does the current in the right branch of the circuit change, and why?

(A) The current does not change, because the total resistance does not change.
(B) The current increases, because the total resistance will always decrease.
(C) The current decreases, because the total resistance will always increase.
(D) The change in current cannot be determined without knowing the resistances of R_1 and R_2.



11. A block of mass 10 kg moves from position A to position B shown in the figure above. The speed of the block is $10\ \text{m/s}$ at A and $4.0\ \text{m/s}$ at B. The work done by friction on the block as it moves from A to B is most nearly

(A) −280 J
(B) −220 J
(C) −200 J
(D) 0 J

---

12. To determine the speed of waves on a string, some students tie a long string of unknown length between a wave generator and a wall. They vary the frequency f of the generator to get a standing wave. They count the nodes n and measure the wavelength λ. They repeat the experiment, creating standing waves with different frequencies. Which of the following is the best relationship to graph to determine the speed of the waves on the string?

(A) f as a function of λ
(B) f as a function of $1/\lambda$
(C) f as a function of n
(D) f as a function of $1/n$

13. A ladder at rest is leaning against a wall at an angle. Which of the following forces must have the same magnitude as the frictional force exerted on the ladder by the floor?

(A) The force of gravity on the ladder
(B) The normal force exerted on the ladder by the floor
(C) The frictional force exerted on the ladder by the wall
(D) The normal force exerted on the ladder by the wall

14. Some students want to calculate the work done by friction as an object with unknown mass moves along a straight line on a rough horizontal surface. The students have a force probe, a meterstick, and a stopwatch. Which of the following will allow the students to take the measurements needed to calculate the work done by friction?

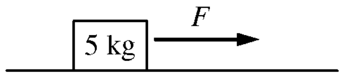
(A) Pulling the block at an unknown constant acceleration with the force probe for a measured time
(B) Pulling the block at an unknown constant speed with the force probe for a measured time
(C) Pulling the block at an unknown constant acceleration with the force probe for a measured distance
(D) Pulling the block at an unknown constant speed with the force probe for a measured distance

15. A pendulum consisting of a sphere suspended from a light string is oscillating with a small angle with respect to the vertical. The sphere is then replaced with a new sphere of the same size but greater density and is set into oscillation with the same angle. How do the period, maximum kinetic energy, and maximum acceleration of the new pendulum compare to those of the original pendulum?

	Period	Maximum Kinetic Energy	Maximum Acceleration
(A)	Larger	Larger	Smaller
(B)	Smaller	Larger	Smaller
(C)	The same	The same	The same
(D)	The same	Larger	The same

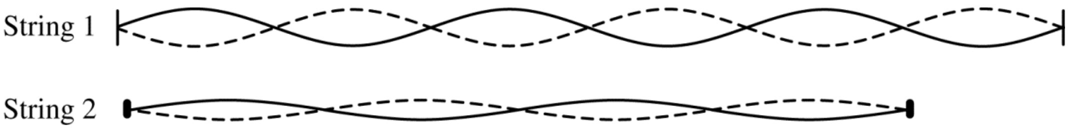
16. Planet X has twice Earth's mass and three times Earth's radius. The magnitude of the gravitational field near Planet X's surface is most nearly

(A) 2 N/kg
(B) 7 N/kg
(C) 10 N/kg
(D) 20 N/kg



17. A force F is exerted on a 5 kg block to move it across a rough surface, as shown above. The magnitude of the force is initially 5 N, and the block moves at a constant velocity. While the block is moving, the force is instantaneously increased to 12 N. How much kinetic energy does the block now gain as it moves a distance of 2 m?

(A) 10 J
(B) 14 J
(C) 24 J
(D) 34 J



18. The figure above represents two guitar strings of different materials and lengths, which are on two guitars of different sizes. String 1 is plucked so it vibrates in the pattern shown. Very soon after string 1 is plucked, string 2, which is a short distance away, vibrates in the pattern shown. The guitars are placed in a sealed chamber and then the air is pumped out of the chamber. String 1 is again plucked and vibrates in the pattern shown. Does string 2 again vibrate in the pattern shown, and why or why not?

(A) Yes, because waves again carry some of the energy produced by string 1 to string 2
(B) Yes, because the strings share the same fundamental frequency
(C) No, because the amplitude of the vibration of string 1 becomes zero too quickly for string 2 to start vibrating
(D) No, because almost no energy associated with the vibration of string 1 reaches string 2

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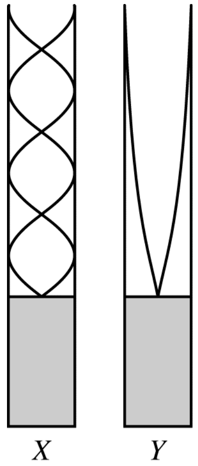


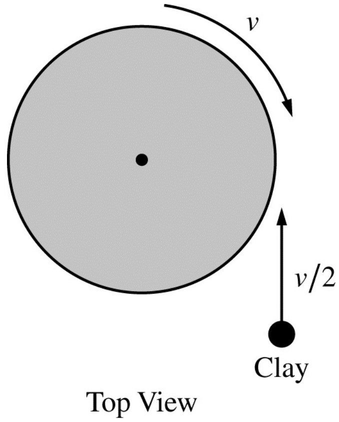
19. The figure above represents standing wave patterns in two identical tubes. The tubes contain the same amount of water, and the standing waves are produced by holding a vibrating tuning fork near the top of each tube. What is the relationship between the wavelengths λ_X and λ_Y of the standing waves?

(A) $\lambda_X = \frac{1}{7}\lambda_Y$

(B) $\lambda_X = \frac{2}{7}\lambda_Y$

(C) $\lambda_X = \frac{7}{2}\lambda_Y$

(D) $\lambda_X = 7\lambda_Y$



20. A system consists of a disk rotating on a frictionless axle and a piece of clay moving toward it, as shown in the figure above. The outside edge of the disk is moving at a linear speed v, and the clay is moving at speed $v/2$. The clay sticks to the outside edge of the disk. How does the angular momentum of the system after the clay sticks compare to the angular momentum of the system before the clay sticks, and what is an explanation for the comparison?

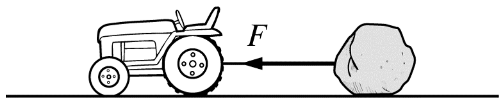
(A) It is the same because there is no external torque acting on the system.
(B) It is greater because the rotating mass increases, which increases the rotational inertia.
(C) It is less because the speed of the disk decreases when the clay sticks to it.
(D) It is less because the angular momentum of the clay opposes that of the disk.

21. A disk of known radius and rotational inertia can rotate without friction in a horizontal plane around its fixed central axis. The disk has a cord of negligible mass wrapped around its edge. The disk is initially at rest, and the cord can be pulled to make the disk rotate. Which of the following procedures would best determine the relationship between applied torque and the resulting change in angular momentum of the disk?

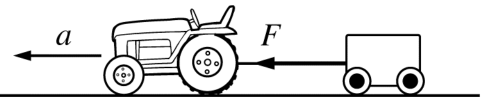
(A) Pulling on the cord, exerting a force of 15 N for 2 s and then 25 N for 3 s, and measuring the final angular velocity of the disk
(B) For five different time intervals, pulling on the cord, exerting a force of 15 N, and then measuring the angle through which the disk rotates in each case
(C) For five different time intervals, pulling on the cord, exerting a force of 15 N, and then measuring the final angular velocity of the disk
(D) For five forces of different magnitude, pulling on the cord for 5 s, and then measuring the final angular velocity of the disk

22. When object X with charge $+2\ \mu\text{C}$ is $1\ \text{m}$ from object Y with charge $-3\ \mu\text{C}$, the magnitude of the force between them is F. Object Y is removed, and object Z with charge $-2\ \mu\text{C}$ is placed $2\ \text{m}$ from object X. What is the magnitude of the force between objects X and Z?

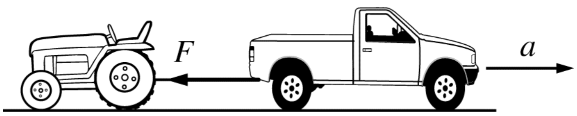
(A) $F/2$
(B) $F/3$
(C) $F/4$
(D) $F/6$



Boulder: Force F to the left
No acceleration



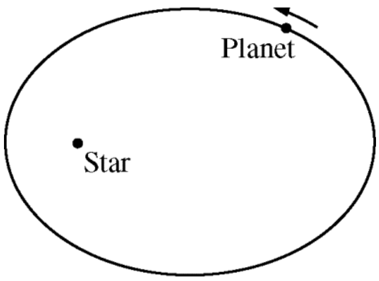
Wagon: Force F to the left
Acceleration a to the left



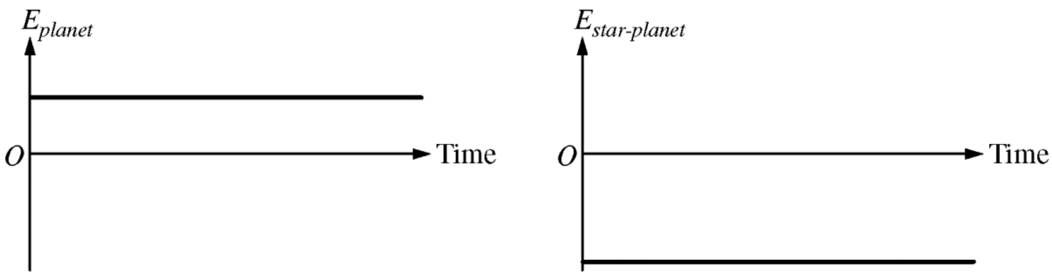
Truck: Force F to the left
Acceleration a to the right

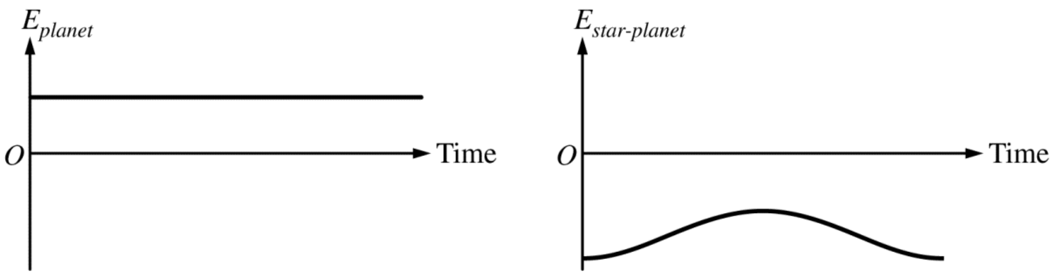
23. Each of the figures above shows a tractor attached to an object. The tractor exerts the same constant force F on each object in every case. Which of the following is a true statement about an object and the relative magnitude of the force exerted by the object on the tractor?

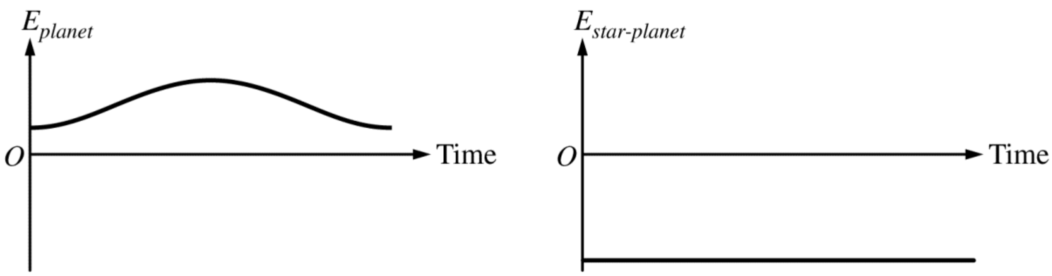
(A) The magnitude of the force exerted by the truck on the tractor is greatest, because the resulting motion is in the direction opposite the tractor's pull.
(B) The magnitude of the force exerted by the boulder on the tractor is least, because no motion results.
(C) The magnitude of the force exerted by the wagon on the tractor is least, because the resulting motion is in the direction of the tractor's pull.
(D) The magnitude of the force exerted by each object on the tractor is equal, because the tractor exerts an equal force on each object.

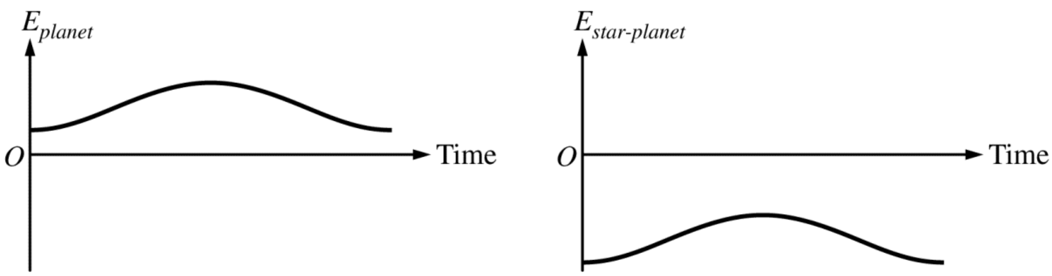


24. A planet is in an elliptical orbit around a star, as shown above. Which of the following best represents the mechanical energy E_{planet} of just the planet and the mechanical energy $E_{star\text{-}planet}$ of the star-planet system as functions of time for one complete orbit?

(A) 

(B) 

(C) 

(D) 

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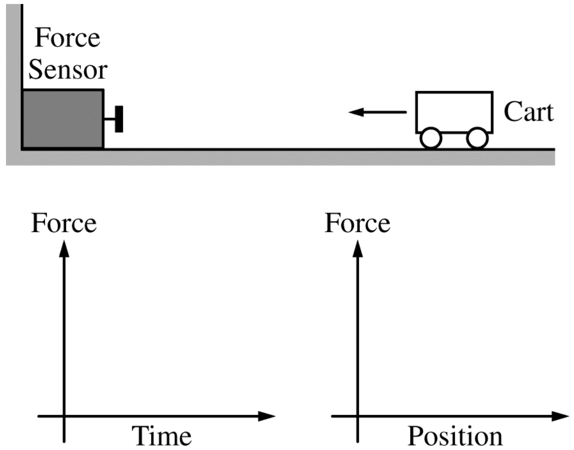
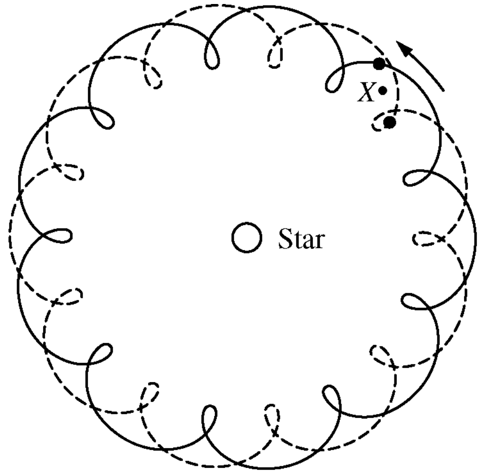


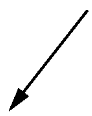
Graph 1 Graph 2

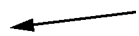
25. A cart of known mass moves with known speed along a level, frictionless track, as shown in the figure above. The cart hits a force sensor and rebounds. The force sensor measures the force exerted on the cart as a function of time and as a function of the position of the cart. The results will be graphed on the axes shown. Which of the two graphs can be used to determine the cart's speed after it rebounds?

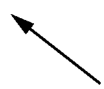
    (A) Only graph 1; graph 2 will have no information useful for finding the speed.
    (B) Only graph 2; graph 1 will have no information useful for finding the speed.
    (C) Either graph 1 or graph 2 can be used.
    (D) Neither graph alone is sufficient; both graph 1 and graph 2 are needed.

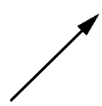


26. The figure above represents the orbits of two planets of equal mass that orbit their star in the counterclockwise direction as a double-planet system. From the point of view of an observer on either planet, the planets appear to orbit each other while also orbiting the star. The dots on the orbits represent the position of the planets at time t_0, and X is the position of their center of mass at that time. Which of the following arrows best represents the acceleration of the center of mass of the double-planet system when it is at point X ?

    (A) 

    (B) 

    (C) 

    (D) 

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27. Two identical blocks are connected to the opposite ends of a compressed spring. The blocks initially slide together on a frictionless surface with velocity v to the right. The spring is then released by remote control. At some later instant, the left block is moving at $v/2$ to the left, and the other block is moving to the right. What is the speed of the center of mass of the system at that instant?

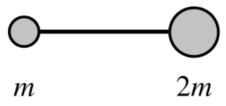
(A) $5v/2$
(B) $3v/2$
(C) v
(D) $v/2$

28. A person holds a book at rest a few feet above a table. The person then lowers the book at a slow constant speed and places it on the table. Which of the following accurately describes the change in the total mechanical energy of the Earth-book system?

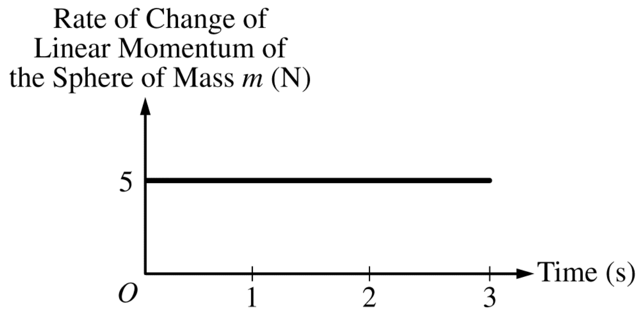
(A) The total mechanical energy is unchanged, because there is no change in the book's kinetic energy as it is lowered to the table.
(B) The total mechanical energy is unchanged, because no work is done on the Earth-book system while the book is lowered.
(C) The total mechanical energy decreases, because the person does positive work on the book by exerting a force that opposes the gravitational force.
(D) The total mechanical energy decreases, because the person does negative work on the book by exerting a force on the book in the direction opposite to its displacement.

GO ON TO THE NEXT PAGE.

Questions 29-30 refer to the following material.



A system consists of two spheres, of mass m and $2m$, connected by a rod of negligible mass, as shown above. The system is held at its center of mass with the rod horizontal and released from rest near Earth's surface at time $t = 0$.



29. The graph above shows the rate of change of linear momentum of the sphere of mass m as a function of time. What is the linear momentum of the two-sphere system at time $t = 3.0$ s ?

(A) 5 kg•m/s
(B) 15 kg•m/s
(C) 45 kg•m/s
(D) 60 kg•m/s

30. Which of the following best explains why the system does not rotate around its center of mass as it falls?

(A) The Earth exerts the same gravitational force on both spheres, causing them to accelerate at the same rate.
(B) The Earth exerts the same gravitational force on both spheres, generating torques that cancel out.
(C) The Earth exerts a larger gravitational force on the sphere of mass $2m$, but that sphere is closer to the center of mass and the torques cancel out.
(D) The Earth exerts a larger gravitational force on the sphere of mass $2m$, but that sphere has more inertia and the torques cancel out.

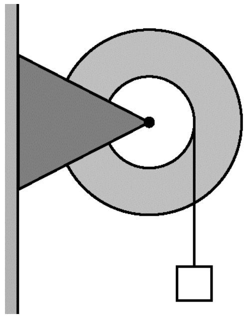
GO ON TO THE NEXT PAGE.

31. A person is running on a track. Which of the following forces propels the runner forward?

(A) The normal force exerted by the ground on the person
(B) The normal force exerted by the person on the ground
(C) The force of friction exerted by the ground on the person
(D) The force of friction exerted by the person on the ground

32. In a one-dimensional perfectly elastic collision, an object of mass m is traveling with speed v_0 in the $+x$-direction when it strikes an object with mass $3m$ that is at rest. What are the objects' velocities following the collision?

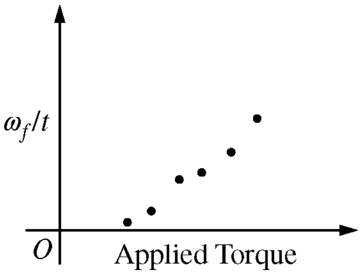
	Object of Mass m	Object of Mass $3m$
(A)	Zero	$v_0/3$, $+x$-direction
(B)	$v_0/4$, $+x$-direction	$v_0/2$, $+x$-direction
(C)	$v_0/2$, $+x$-direction	$v_0/2$, $+x$-direction
(D)	$v_0/2$, $-x$-direction	$v_0/2$, $+x$-direction



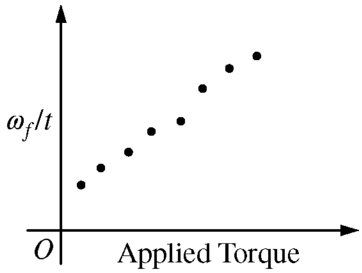
33. A student conducts an experiment to determine the relationship between applied torque and change in angular velocity. The student uses the apparatus shown in the figure above, consisting of two disks that are glued together and mounted on a horizontal axle. Blocks of varying mass are hung from a string wound around the smaller disk. The blocks are released from rest, exerting different torques on the disks, and are allowed to fall a fixed distance. For each block, the time of fall t and the final angular velocity ω_f of the disks are measured.

There is considerable friction between the disks and the axle. Which of the following best represents a plot that can be obtained from the student's data?

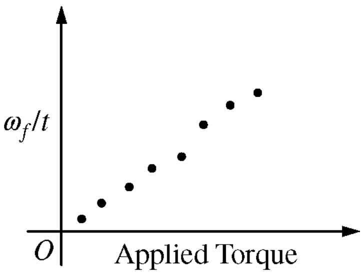
(A)



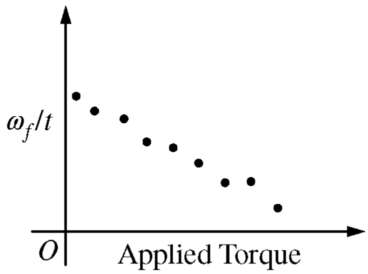
(B)

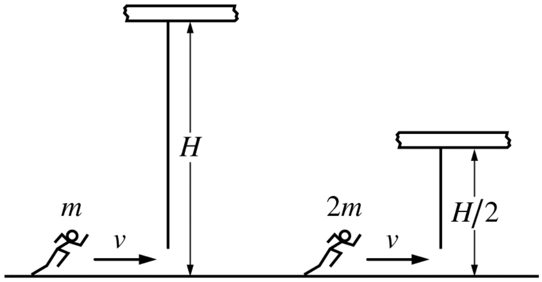


(C)



(D)

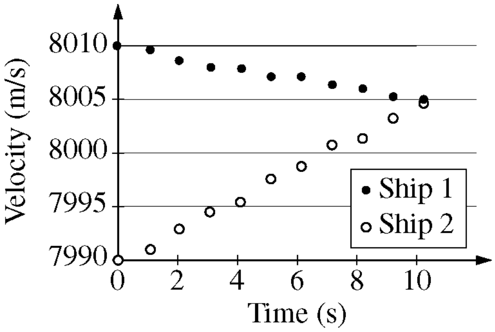




34. An athlete with mass m running at speed v grabs a light rope that hangs from a ceiling of height H and swings to a maximum height of h_1. In another room with a lower ceiling of height $H/2$, a second athlete with mass $2m$ running at the same speed v grabs a light rope hanging from the ceiling and swings to a maximum height of h_2. How does the maximum height reached by the two athletes compare, and why?

    (A) The first athlete reaches a greater height, because this athlete swings on a longer rope.
    (B) The second athlete reaches a greater height, because this athlete has a greater mass.
    (C) The two athletes reach the same height, because the effect of the rope length offsets the effect of the athletes' masses.
    (D) The two athletes reach the same height, because the athletes run with the same speed.

Questions 35-36 refer to the following material.

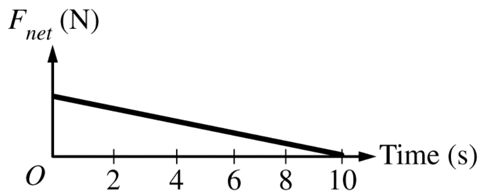


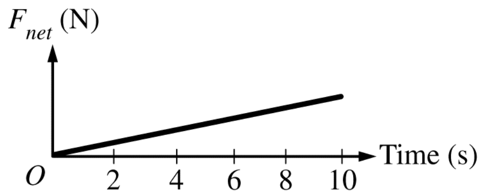
Two identical spaceships are traveling in deep space, far from any planets or stars. The ships travel in the same direction, with the slower one directly behind the faster one. The ships are connected by a cable attached to a spool, so that the part of the cable outside the ships can be made longer or shorter as needed. The cable is used to bring the ships to the same speed for a transfer of cargo. The graph above shows the speed of the two ships during a 10 s interval.

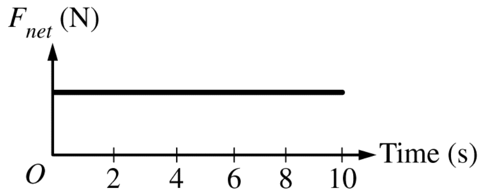
35. Does at least one of the ships have its engine turned on during the time interval shown, and what evidence indicates so?

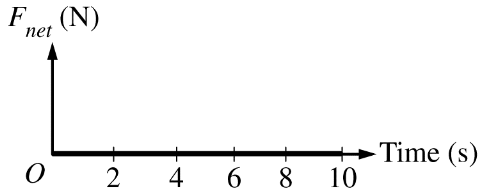
(A) Yes, because Ship 2 is speeding up.
(B) Yes, because the momentum of the two-rocket system increases.
(C) Yes, because an engine is needed to keep the system moving.
(D) No, because the cable alone could be responsible for making Ship 1 slow down and Ship 2 speed up.

36. Which of the following graphs best represents the net force F_{net} exerted on the two-ship system?

(A)


(B)


(C)


(D)


GO ON TO THE NEXT PAGE.

Directions: For each of the questions or incomplete statements below, two of the suggested answers will be correct. For each of these questions, you must select both correct choices to earn credit. No partial credit will be earned if only one correct choice is selected. Select the two that are best in each case and then fill in the corresponding circles that begin with number 131 on page 3 of the answer sheet.

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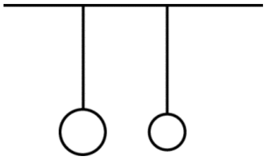
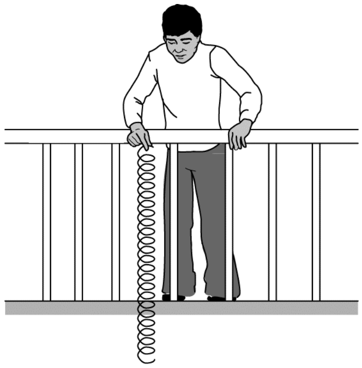


131. Two hollow, uncharged conducting spheres hang by threads from the ceiling, as shown above. The spheres have the same mass but are different sizes. A charge $+Q$ is deposited on the larger sphere. The spheres are then momentarily brought into contact and separated, after which they move away from each other. Which of the following statements about the final state of the spheres and strings must be true? Select two answers.

(A) The spheres have charges of opposite sign.
(B) The sum of the charges on the spheres is $+Q$.
(C) The tension in each string is larger than it was initially.
(D) The force exerted by the ceiling on each string is directed vertically upward.



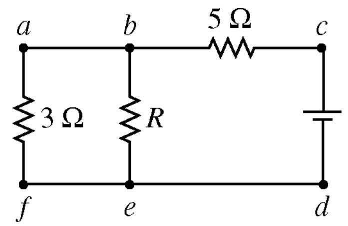
132. A student wants to demonstrate a transverse wave for a friend. The student holds a long spring with his fingertips and lets it hang vertically over the edge of a railing, as shown above. The student can move his hand in a way that creates waves that propagate down the spring. Which of the following movements of the student's hand will create a transverse wave? Select two answers.

(A) Left and right
(B) Forward and backward
(C) Up and down
(D) Releasing the spring

GO ON TO THE NEXT PAGE.

133. Suppose two square wave pulses that are in the same plane could be created on a string, one with a maximum displacement of 4 cm and the other with a maximum displacement of 2 cm. Which of the following is a possible displacement of the string when the wave pulses overlap? Select two answers.

(A) 2 cm
(B) 3 cm
(C) 6 cm
(D) 8 cm



134. The figure above shows a circuit with three resistors—two with known resistance and one with unknown resistance—and a battery with unknown potential difference. Which of the following sets of measurements of potential difference will allow determination of the unknown resistance R ? Select two answers.

(A) Between points b and e only
(B) Between points a and f and between points b and c
(C) Between points b and c and between points c and d
(D) Between points a and f and between points b and e

GO ON TO THE NEXT PAGE.

END OF SECTION I

**IF YOU FINISH BEFORE TIME IS CALLED,
YOU MAY CHECK YOUR WORK ON THIS SECTION.**

DO NOT GO ON TO SECTION II UNTIL YOU ARE TOLD TO DO SO.

MAKE SURE YOU HAVE DONE THE FOLLOWING.

- **PLACED YOUR AP NUMBER LABEL ON YOUR ANSWER SHEET**
- **WRITTEN AND GRIDDED YOUR AP NUMBER CORRECTLY ON YOUR ANSWER SHEET**
- **TAKEN THE AP EXAM LABEL FROM THE FRONT OF THIS BOOKLET AND PLACED IT ON YOUR ANSWER SHEET.**

Section II: Free-Response Questions

This is the free-response section of the 2015 AP exam.
It includes cover material and other administrative instructions
to help familiarize students with the mechanics of the exam.
(Note that future exams may differ in look from the following content.)

AP® Physics 1: Algebra-Based Exam

SECTION II: Free Response

2015

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

At a Glance

Total Time
1 hour, 30 minutes
Number of Questions
5
Percent of Total Score
50%
Writing Instrument
Either pencil or pen with black or dark blue ink
Electronic Device
Calculator allowed
Suggested Time
Approximately 25 minutes each for questions 2 and 3 and 13 minutes each for questions 1, 4, and 5
Weight
Approximate weights:
Questions 2 and 3: 26% each
Questions 1, 4, and 5: 16% each

IMPORTANT Identification Information

PLEASE PRINT WITH PEN:

1. First two letters of your last name ☐☐

   First letter of your first name ☐

2. Date of birth

   ☐☐ Month ☐☐ Day ☐☐☐☐ Year

3. Six-digit school code

   ☐☐☐☐☐☐

4. Unless I check the box below, I grant the College Board the unlimited right to use, reproduce, and publish my free-response materials, both written and oral, for educational research and instructional purposes. My name and the name of my school will not be used in any way in connection with my free-response materials. I understand that I am free to mark "No" with no effect on my score or its reporting.

   No, I do not grant the College Board these rights. ☐

Instructions

The questions for Section II are printed in this booklet. You may use any blank space in the booklet for scratch work, but you must write your answers in the spaces provided for each answer. A table of information and lists of equations that may be helpful are in the booklet. Calculators, rulers, and straightedges may be used in this section.

All final numerical answers should include appropriate units. Credit for your work depends on demonstrating that you know which physical principles would be appropriate to apply in a particular situation. Therefore, you should show your work for each part in the space provided after that part. If you need more space, be sure to clearly indicate where you continue your work. Credit will be awarded only for work that is clearly designated as the solution to a specific part of a question. Credit also depends on the quality of your solutions and explanations, so you should show your work.

Write clearly and legibly. Cross out any errors you make; erased or crossed-out work will not be scored. You may lose credit for incorrect work that is not crossed out.

Manage your time carefully. You may proceed freely from one question to the next. You may review your responses if you finish before the end of the exam is announced.

Form I
Form Code 4LBP4-S

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AP® PHYSICS 1 TABLE OF INFORMATION

CONSTANTS AND CONVERSION FACTORS	
Proton mass, $m_p = 1.67 \times 10^{-27}$ kg	Electron charge magnitude, $e = 1.60 \times 10^{-19}$ C
Neutron mass, $m_n = 1.67 \times 10^{-27}$ kg	Coulomb's law constant, $k = 1/4\pi\varepsilon_0 = 9.0 \times 10^{9}\ \text{N}\cdot\text{m}^2/\text{C}^2$
Electron mass, $m_e = 9.11 \times 10^{-31}$ kg	Universal gravitational constant, $G = 6.67 \times 10^{-11}\ \text{m}^3/\text{kg}\cdot\text{s}^2$
Speed of light, $c = 3.00 \times 10^{8}$ m/s	Acceleration due to gravity at Earth's surface, $g = 9.8\ \text{m/s}^2$

UNIT SYMBOLS								
	meter,	m	kelvin,	K	watt,	W	degree Celsius,	°C
	kilogram,	kg	hertz,	Hz	coulomb,	C		
	second,	s	newton,	N	volt,	V		
	ampere,	A	joule,	J	ohm,	Ω		

PREFIXES		
Factor	Prefix	Symbol
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p

VALUES OF TRIGONOMETRIC FUNCTIONS FOR COMMON ANGLES

θ	0°	30°	37°	45°	53°	60°	90°
$\sin\theta$	0	$1/2$	$3/5$	$\sqrt{2}/2$	$4/5$	$\sqrt{3}/2$	1
$\cos\theta$	1	$\sqrt{3}/2$	$4/5$	$\sqrt{2}/2$	$3/5$	$1/2$	0
$\tan\theta$	0	$\sqrt{3}/3$	$3/4$	1	$4/3$	$\sqrt{3}$	∞

The following conventions are used in this exam.

I. The frame of reference of any problem is assumed to be inertial unless otherwise stated.
II. Assume air resistance is negligible unless otherwise stated.
III. In all situations, positive work is defined as work done <u>on</u> a system.
IV. The direction of current is conventional current: the direction in which positive charge would drift.
V. Assume all batteries and meters are ideal unless otherwise stated.

AP® PHYSICS 1 EQUATIONS

MECHANICS

$$v_x = v_{x0} + a_x t$$

$$x = x_0 + v_{x0} t + \frac{1}{2} a_x t^2$$

$$v_x^2 = v_{x0}^2 + 2a_x (x - x_0)$$

$$\vec{a} = \frac{\sum \vec{F}}{m} = \frac{\vec{F}_{net}}{m}$$

$$\left|\vec{F}_f\right| \le \mu \left|\vec{F}_n\right|$$

$$a_c = \frac{v^2}{r}$$

$$\vec{p} = m\vec{v}$$

$$\Delta\vec{p} = \vec{F}\,\Delta t$$

$$K = \frac{1}{2} m v^2$$

$$\Delta E = W = F_{\parallel} d = F d \cos\theta$$

$$P = \frac{\Delta E}{\Delta t}$$

$$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$$

$$\omega = \omega_0 + \alpha t$$

$$x = A\cos(2\pi f t)$$

$$\vec{\alpha} = \frac{\sum \vec{\tau}}{I} = \frac{\vec{\tau}_{net}}{I}$$

$$\tau = r_{\perp} F = r F \sin\theta$$

$$L = I\omega$$

$$\Delta L = \tau\,\Delta t$$

$$K = \frac{1}{2} I \omega^2$$

$$\left|\vec{F}_s\right| = k\left|\vec{x}\right|$$

$$U_s = \frac{1}{2} k x^2$$

$$\rho = \frac{m}{V}$$

a = acceleration
A = amplitude
d = distance
E = energy
f = frequency
F = force
I = rotational inertia
K = kinetic energy
k = spring constant
L = angular momentum
ℓ = length
m = mass
P = power
p = momentum
r = radius or separation
T = period
t = time
U = potential energy
V = volume
v = speed
W = work done on a system
x = position
y = height
α = angular acceleration
μ = coefficient of friction
θ = angle
ρ = density
τ = torque
ω = angular speed

$$\Delta U_g = m g \Delta y$$

$$T = \frac{2\pi}{\omega} = \frac{1}{f}$$

$$T_s = 2\pi\sqrt{\frac{m}{k}}$$

$$T_p = 2\pi\sqrt{\frac{\ell}{g}}$$

$$\left|\vec{F}_g\right| = G\frac{m_1 m_2}{r^2}$$

$$\vec{g} = \frac{\vec{F}_g}{m}$$

$$U_G = -\frac{G m_1 m_2}{r}$$

ELECTRICITY

$$\left|\vec{F}_E\right| = k\left|\frac{q_1 q_2}{r^2}\right|$$

$$I = \frac{\Delta q}{\Delta t}$$

$$R = \frac{\rho \ell}{A}$$

$$I = \frac{\Delta V}{R}$$

$$P = I\,\Delta V$$

$$R_s = \sum_i R_i$$

$$\frac{1}{R_p} = \sum_i \frac{1}{R_i}$$

A = area
F = force
I = current
ℓ = length
P = power
q = charge
R = resistance
r = separation
t = time
V = electric potential
ρ = resistivity

WAVES

$$\lambda = \frac{v}{f}$$

f = frequency
v = speed
λ = wavelength

GEOMETRY AND TRIGONOMETRY

Rectangle
$A = bh$

Triangle
$A = \frac{1}{2} bh$

Circle
$A = \pi r^2$
$C = 2\pi r$

Rectangular solid
$V = \ell wh$

Cylinder
$V = \pi r^2 \ell$
$S = 2\pi r \ell + 2\pi r^2$

Sphere
$V = \frac{4}{3}\pi r^3$
$S = 4\pi r^2$

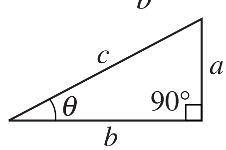
A = area
C = circumference
V = volume
S = surface area
b = base
h = height
ℓ = length
w = width
r = radius

Right triangle
$c^2 = a^2 + b^2$

$\sin\theta = \frac{a}{c}$

$\cos\theta = \frac{b}{c}$

$\tan\theta = \frac{a}{b}$



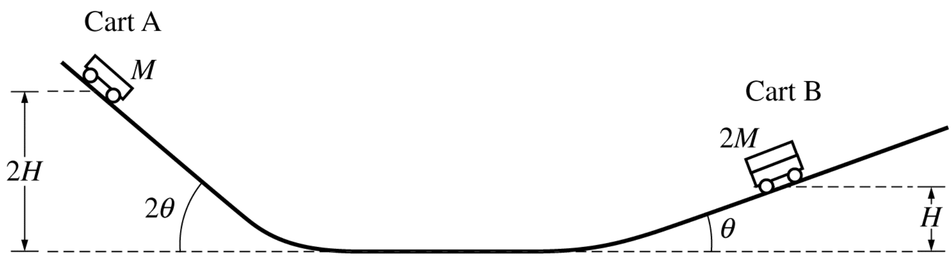
PHYSICS 1

Section II

5 Questions

Time—90 minutes

Directions: Questions 1, 4 and 5 are short free-response questions that require about 13 minutes each to answer and are worth 7 points each. Questions 2 and 3 are long free-response questions that require about 25 minutes each to answer and are worth 12 points each. Show your work for each part in the space provided after that part.



1. (7 points, suggested time 13 minutes)

   Cart A has mass M and is released from rest at a height $2H$ on a ramp making an angle 2θ with the horizontal, as shown above. Cart B has mass $2M$ and is released from rest at a height H on a ramp making an angle θ with the horizontal. The carts roll toward each other, have a head-on collision on the horizontal portion of the ramp, and stick together. The masses of the carts' wheels are negligible, as are any frictional or drag forces.

   (a) Indicate whether the carts remain at rest, move to the left, or move to the right after the collision.

   ____ Remain at rest ____ Move to the left ____ Move to the right

   Explain how you arrived at your answer.

GO ON TO THE NEXT PAGE.

(b) Consider the time interval from when the two carts are released until just after they collide.

i. For the system consisting of the two carts and Earth, indicate whether the total mechanical energy increases, decreases, or remains the same.

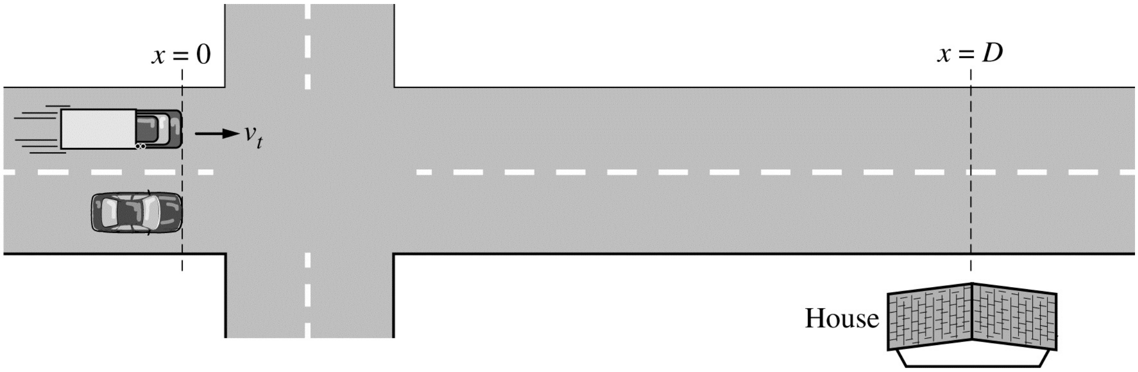
____ Increases ____ Decreases ____ Remains the same

Justify your answer.

ii. For the system consisting of only the two carts, indicate whether the total mechanical energy increases, decreases, or remains the same.

____ Increases ____ Decreases ____ Remains the same

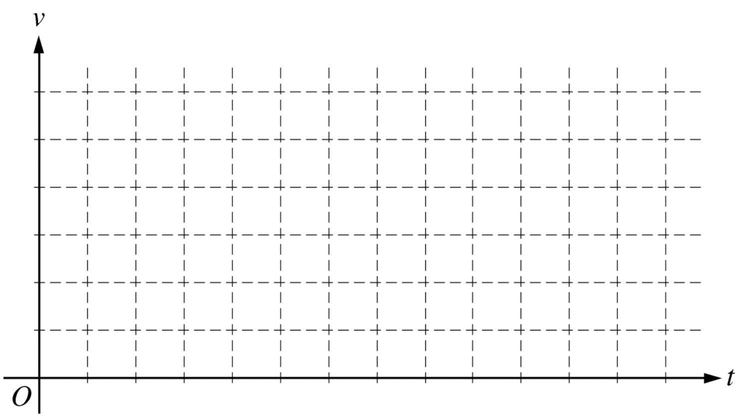
Justify your answer.



2. (12 points, suggested time 25 minutes)

A car is stopped at a traffic light. The light turns green, and at time $t = 0$ the car starts moving and travels with a constant acceleration. At that instant a truck traveling at constant speed v_t is alongside the car, with the front of each vehicle at position $x = 0$, as shown above. The truck passes the car, but the car later catches up to the truck in front of a house, such that at time t_D the front of each vehicle is at position $x = D$.

(a) On the axes below, sketch and label graphs of the velocity of the car and the velocity of the truck as a function of time. Indicate any important velocities or times.



GO ON TO THE NEXT PAGE.

(b) Two students are discussing how the speed of the car compares to the speed of the truck when both vehicles are in front of the house.

Student 1 says, “The distance traveled by the car and the truck is the same, and the time is the same, so they must have the same speed.”

Student 2 says, “I don’t see how that can be. The car catches up to the truck, so the car has to be going faster.”

i. Which aspects of Student 1’s reasoning, if any, are correct? Support your answer in terms of relevant features of your graphs in part (a).

ii. Which aspects of Student 2’s reasoning, if any, are correct? Support your answer in terms of relevant features of your graphs in part (a).

(c) Derive an expression for the acceleration of the car. Express your answer in terms of D and v_t.

(d) Determine the time at which the speed of the car is equal to the speed v_t of the truck. Express your answer in terms of t_D. Justify your answer.

3. (12 points, suggested time 25 minutes)

You are given a long length of string and an oscillator that can shake one end of the string at any desired frequency. The oscillator has a display that indicates the frequency. You are asked to design an experiment to study how the velocity of waves on the string depends on the string's tension. You do not have any way to measure time with sufficient accuracy to help in your investigation.

(a) Describe your experimental setup and procedure, including any additional pieces of equipment you would need and the kind of data you would record. Include enough detail that another student could follow and complete the experiment successfully.

(b) Describe how you would analyze your data to obtain information about the wave velocity's dependence on tension.

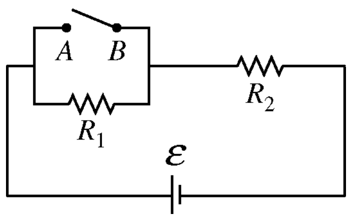
(c) A student performs the experiment and can see from the data table below that the velocity of the waves on the string increases when the tension in the string increases. The student claims that the velocity is directly proportional to the tension. Do the results support the student's claim? Explain in detail how you arrived at your answer.

Velocity (m/s)	17	24	29	34	38
Tension (N)	2.0	4.0	6.0	8.0	10.0

(d) After the experiment is completed, a student attaches a string to the wall and the other end of the string to an oscillator. The frequency of the oscillator is adjusted to make a standing wave. The string is allowed to vibrate in a standing wave with constant amplitude.

i. While the string is vibrating as a standing wave with constant amplitude, is the oscillator doing work on the string? Explain your reasoning.

ii. While the string is vibrating as a standing wave with constant amplitude, is the string gaining mechanical energy? Explain your reasoning.



4. (7 points, suggested time 13 minutes)

The circuit shown above contains two resistors, an ideal battery, and a switch. The resistance of resistor R_1 is less than the resistance of resistor R_2.

(a) Indicate whether the current through resistor R_2 when the switch is open is greater than, less than, or equal to the current through resistor R_2 when the switch is closed.

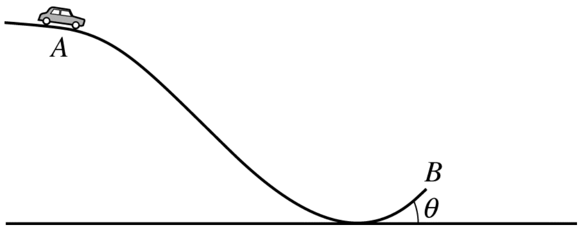
____ Greater than ____ Less than ____ Equal to

Briefly explain how you arrived at your answer.

(b) Closing the switch creates a short circuit. Indicate whether the absolute value of the potential difference between points A and B when the switch is open is greater than, less than, or equal to the absolute value of the potential difference when the switch is closed.

____ Greater than ____ Less than ____ Equal to

Explain your reasoning in a clear, coherent paragraph-length explanation that may also contain equations and/or drawings. Address the conditions before and after the switch is closed.



5. (7 points, suggested time 13 minutes)

A toy car coasts along the curved track shown above. The car has initial speed v_A when it is at point A at the top of the track, and the car leaves the track at point B with speed v_B at an angle θ above the horizontal. Assume that the rotational kinetic energy of the car's wheels and energy losses due to friction are both negligible.

(a) Suppose the toy car is released from rest at point A $(v_A = 0)$.

i. After the car leaves the track and reaches the highest point in its trajectory it will be at a different height than it was at point A. Briefly explain why this is so.

ii. Determine the speed of the car when it is at the highest point in its trajectory after leaving the track, in terms of v_B and θ. Briefly explain how you arrived at your answer.

(b) Suppose the toy car is given an initial push so that it has nonzero speed at point A. Determine the speed v_A of the car at point A such that the highest point in its trajectory after leaving the track is the same as its height at point A. Express your answer in terms of v_B and θ. Explain how you arrived at your answer.

THIS PAGE MAY BE USED FOR SCRATCH WORK.

STOP

END OF EXAM

IF YOU FINISH BEFORE TIME IS CALLED,
YOU MAY CHECK YOUR WORK ON THIS SECTION.

THE FOLLOWING INSTRUCTIONS APPLY TO THE COVERS OF THE SECTION II BOOKLET.

- **MAKE SURE YOU HAVE COMPLETED THE IDENTIFICATION INFORMATION AS REQUESTED ON THE FRONT AND BACK COVERS OF THE SECTION II BOOKLET.**
- **CHECK TO SEE THAT YOUR AP NUMBER LABEL APPEARS IN THE BOX ON THE FRONT COVER.**
- **MAKE SURE YOU HAVE USED THE SAME SET OF AP NUMBER LABELS ON ALL AP EXAMS YOU HAVE TAKEN THIS YEAR.**

Multiple-Choice Answer Key

The following contains the answers to
the multiple-choice questions in this exam.

Answer Key for AP Physics 1 Practice Exam, Section I

Question 1: C
Question 2: A
Question 3: C
Question 4: C
Question 5: D
Question 6: *
Question 7: C
Question 8: B
Question 9: B
Question 10: D
Question 11: B
Question 12: B
Question 13: D
Question 14: D
Question 15: D
Question 16: A
Question 17: B
Question 18: D
Question 19: A
Question 20: A
Question 21: D
Question 22: D
Question 23: D
Question 24: C
Question 25: C
Question 26: A
Question 27: C
Question 28: D
Question 29: C
Question 30: C
Question 31: C
Question 32: D
Question 33: A
Question 34: D
Question 35: B
Question 36: C
Question 131: B, C
Question 132: A, B
Question 133: A, C
Question 134: B, C

*Item 6 was not scored.

Free-Response Scoring Guidelines

The following contains the scoring guidelines
for the free-response questions in this exam.

GENERAL NOTES ABOUT 2015 PHYSICS SCORING GUIDELINES

1. The solutions contain the most common method of solving the free-response questions and the allocation of points for this solution. Some also contain a common alternate solution. Other methods of solution also receive appropriate credit for correct work.

2. Generally, double penalty for errors is avoided. For example, if an incorrect answer to part (a) is correctly substituted into an otherwise correct solution to part (b), full credit will usually be awarded. One exception to this may be cases when the numerical answer to a later part should be easily recognized as wrong, e.g., a speed faster than the speed of light in vacuum.

3. Implicit statements of concepts normally receive credit. For example, if use of the equation expressing a particular concept is worth one point, and a student's solution contains the application of that equation to the problem but the student does not write the basic equation, the point is still awarded. However, when students are asked to derive an expression it is normally expected that they will begin by writing one or more fundamental equations, such as those given on the exam equation sheet. For a description of the use of such terms as "derive" and "calculate" on the exams, and what is expected for each, see "The Free-Response Sections—Student Presentation" in the *AP Physics; Physics C: Mechanics, Physics C: Electricity and Magnetism Course Description* or "Terms Defined" in the *AP Physics 1: Algebra-Based and AP Physics 2: Algebra-Based Course and Exam Description*.

4. The scoring guidelines typically show numerical results using the value $g = 9.8 \text{ m/s}^2$, but use of 10 m/s^2 is of course also acceptable. Solutions usually show numerical answers using both values when they are significantly different.

5. Strict rules regarding significant digits are usually not applied to numerical answers. However, in some cases answers containing too many digits may be penalized. In general, two to four significant digits are acceptable. Numerical answers that differ from the published answer due to differences in rounding throughout the question typically receive full credit. Exceptions to these guidelines usually occur when rounding makes a difference in obtaining a reasonable answer. For example, suppose a solution requires subtracting two numbers that should have five significant figures and that differ starting with the fourth digit (e.g., 20.295 and 20.278). Rounding to three digits will lose the accuracy required to determine the difference in the numbers, and some credit may be lost.

Question 1

7 points total | **Distribution of points**

(a) 3 points

For any application of conservation of energy	1 point
For correctly applying conservation of energy for each cart	1 point
For any application of conservation of momentum	1 point

Example 1: The contributions of each cart to the potential energy of the carts-Earth system when the carts are at their points of release are the same, because one has twice the height and one has twice the mass of the other. All this potential energy is converted into kinetic energy when the carts reach the bottom of the ramp, so the carts have the same kinetic energy there. This means that the speed of cart A is 1.4 times the speed of Cart B. Before the collision, cart A has a momentum of about $1.4Mv$ to the right; cart B has a momentum of $2Mv$ to the left. The net momentum is to the left, so after the collision the carts move left.

Example 2:

$$Mg(2H) = Mv_A^2/2 \; ; \qquad v_A^2 = 4gH \; ; \quad v_A = 2\sqrt{gH}$$

$$2Mg(H) = (2M)v_B^2/2 \; ; \quad v_B^2 = 2gH \; ; \quad v_B = \sqrt{2gH}$$

$$M(2\sqrt{gH}) - 2M(\sqrt{2gH}) = (M + 2M)v_f = 3Mv_f$$

$$v_f = \left(\frac{2 - 2\sqrt{2}}{3}\right)\sqrt{gH} = -\frac{0.83}{3}\sqrt{gH} = -0.28\sqrt{gH}$$

One earned point is deducted for any incorrect use of ramp angles.

(b)

i. 2 points

For indicating that no energy is gained as the carts move down the ramps, or using the result of the reasoning in part (a) regarding the energy for this part of the motion	1 point
For indicating that energy is dissipated in the collision and a comparison of initial and final energies consistent with the students' assumptions about energy before the collision	1 point

ii. 2 points

For indicating that the initial mechanical energy of the carts is zero	1 point
For a comparison with the energy after the collision consistent with previous responses	1 point

Example: When the carts are released, they have no mechanical energy, since they are not moving. After the collision, the carts have kinetic energy. The total mechanical energy of the cart-cart system increases.

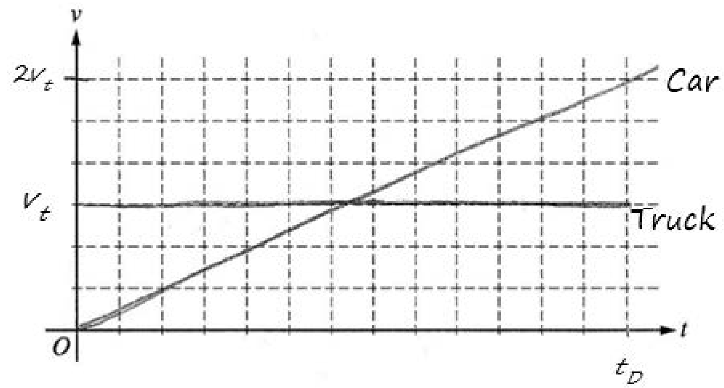
Alternate solution	*Alternate points*
For identifying gravitational force as the only external force doing work	*1 point*
For correct use of the work-kinetic energy theorem	*1 point*

Example: For the system of just the two carts, there is no initial mechanical energy, since the carts are at rest. The gravitational force exerted on the carts by Earth is the only external force doing work, and the work on the system is positive. So the kinetic energy of the system increases, which increases the total mechanical energy.

Question 2

12 points total **Distribution of points**

(a) 3 points



For a clearly labeled horizontal line for the truck	1 point
For a clearly labeled straight line with positive slope for the car	1 point
For the speed of the car ending higher than the speed of the truck at a time labeled to indicate that the house has been reached	1 point

(b)

i. 2 points

For indicating that student 1 is correct that the car and truck travel the same distance in the same time	1 point
For identifying a feature of the graph that supports this: e.g., the area under both curves is the same, or the visual average of the speed of the car is the same as the speed of the truck	1 point

ii. 2 points

For indicating that student 2 is correct that the car's speed is greater when the vehicles are in front of the house	1 point
For identifying a feature of the graph that supports this: e.g., the final speed of the car is twice the speed of the truck	1 point

(c) 3 points

For indicating that the final speed of the car is twice the speed of truck — 1 point

For applying any other appropriate kinematic relationship(s) — 1 point

$$(2v_t)^2 = v_{c0}^2 + 2aD$$

For solving for the acceleration in terms of D and v_t — 1 point

$$a = 2v_t^2 / D$$

Question 2 (continued)

	Distribution of points
(d) 2 points	
For indicating that the car and truck have the same speed at $t = t_D/2$	1 point
For a correct justification	1 point

Examples:

That's where the graphs intersect.

At t_D the car's speed is twice the truck's speed, so they'll be equal at $t_D/2$.

Question 3

12 points total	**Distribution of points**
(a) 3 points	
For describing a method for setting and changing the tension in the string (e.g., hanging the string over a pulley and attaching an object whose mass has been measured, then using objects of different mass)	1 point
For using the oscillator to create a wave on the string, adjusting the frequency of the oscillator or the length of the string for each tension until a standing wave is established	1 point
For describing a method for measuring quantities relevant to determining the wavelength of the standing wave formed on the string (e.g., measuring the length of the string with a meter stick and counting the number of nodes)	1 point
(b) 3 points	
For describing a correct method of calculating the propagation speed of the wave which includes either measurement or calculation of the wavelength of the standing wave	1 point
For describing a correct method of calculating or measuring tension (e.g., when using objects of different mass, calculate $F_T = mg$)	1 point
For describing a correct method of analyzing the relationship between the wave velocity and tension (e.g. graph velocity as a function of tension)	1 point
(c) 2 points	
For a reasonable attempt to check whether velocity and tension are directly proportional	1 point
For a valid justification leading to the conclusion that velocity and tension are not directly proportional (e.g., best-fit line for a plot of the data does not go through zero; doubling tension does not result in doubled propagation speed)	1 point
(d) i. 2 points	
The oscillator is doing work on the string.	
For indicating that oscillator generates the wave by applying a force to the string over a distance	1 point
For indicating that work is the product of the applied force and the distance over which it is applied	1 point
Alternate solution	*Alternate points*
For indicating that resistive forces will take energy away from the string	*1 point*
For indicating that if the amplitude is constant the oscillator is supplying energy by doing work on the string	*1 point*

Question 3 (continued)

	Distribution of points
(d) (continued)	
ii. 2 points	
The string is not gaining mechanical energy.	
For indicating that the energy carried by a mechanical wave is related to its amplitude, and having no incorrect or irrelevant statements	1 point
For indicating that the wave does not gain mechanical energy because its amplitude is constant	1 point

Question 4

7 points total | **Distribution of points**

(a) 2 points

The correct answer is "Less than".

For a correct justification leading to a correct conclusion — 2 points

Example: The current through R_2 when the switch is open is less than when the switch is closed, because the total resistance of the circuit with the switch closed is less.

Note: One point can be earned for a reasonable but incorrect justification that is correctly used.

Examples:

The current through R_2 is the same when the switch is open or when the switch is closed, because regardless of whether the switch is open or closed, any current that is split between R_1 and AB must combine again as it moves through R_2.

The current through R_2 when the switch is open is greater than when the switch is closed, because closing the switch adds an additional path for current flow.

(b) 5 points

When the switch is open:

For indicating that there is a potential difference across R_1 because the full current through the battery flows through the resistor — 1 point

For indicating that the potential difference across the switch is equal to the potential difference across R_1 — 1 point

When the switch is closed:

For indicating that the resistance of the switch is zero or negligible, or assuming the switch has resistance and indicating that the resistance of the parallel combination of the switch and resistor is less than that of the resistor alone — 1 point

For indicating implicitly or explicitly that the potential difference across the switch is zero (or negligible), because all (or some) current goes through the switch that has no (or little) resistance and zero (or little) current goes through R_1 — 1 point

For a complete explanation having no incorrect or physically irrelevant statements and indicating that the potential difference across the switch is greater when the switch is open — 1 point

Question 5

7 points total	**Distribution of points**
(a)	
i. 2 points	
For indicating that the mechanical energy of the car-Earth system is constant between point A and the highest point in the car's trajectory	1 point
For indicating that the car is still moving at its highest point and has some kinetic energy so the car-Earth system must have less gravitational potential energy, therefore must be at a lower height than it was at point A	1 point
ii. 2 points	
For indicating that the velocity of the car at its highest point is equal to the horizontal speed at point B	1 point
For stating that the speed at the highest point is $v_B \cos\theta$	1 point
(b) 3 points	
For implicitly or explicitly applying conservation of energy	1 point
For implicitly or explicitly indicating that the gravitational potential energy is the same at the beginning and at the end	1 point
For indicating that the speed is the same at the beginning and at the end, so $v_A = v_B \cos\theta$, or consistent with the answer in part (a-ii)	1 point

Scoring Worksheet

The following provides a scoring worksheet and conversion table used for calculating a composite score of the exam.

2015 AP Physics 1 Scoring Worksheet

Section I: Multiple Choice

__________ × 1.0256 = ______________

Number Correct (out of 39*)

Weighted Section I Score (Do not round)

Section II: Free Response

Question 1	______ (out of 7)	× 0.8888	=	______ (Do not round)
Question 2	______ (out of 12)	× 0.8888	=	______ (Do not round)
Question 3	______ (out of 12)	× 0.8888	=	______ (Do not round)
Question 4	______ (out of 7)	× 0.8888	=	______ (Do not round)
Question 5	______ (out of 7)	× 0.8888	=	______ (Do not round)

Sum = __________

Weighted Section II Score (Do not round)

Composite Score

__________ + __________ = __________

Weighted Section I Score

Weighted Section II Score

Composite Score (Round to nearest whole number)

AP Score Conversion Chart
Physics 1

Composite Score Range	AP Score
51-80	5
39-50	4
29-38	3
20-28	2
0-19	1

*Although 40 multiple-choice items were administered in Section I, item 6 was not used in scoring.

AP Physics 1: Algebra-Based

The College Board

The College Board is a mission-driven not-for-profit organization that connects students to college success and opportunity. Founded in 1900, the College Board was created to expand access to higher education. Today, the membership association is made up of over 6,000 of the world's leading educational institutions and is dedicated to promoting excellence and equity in education. Each year, the College Board helps more than seven million students prepare for a successful transition to college through programs and services in college readiness and college success — including the SAT® and the Advanced Placement Program®. The organization also serves the education community through research and advocacy on behalf of students, educators, and schools. The College Board is committed to the principles of excellence and equity, and that commitment is embodied in all of its programs, services, activities, and concerns.